Cryogenic Summary - Testing D2L107 in MAGCOOL

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9/30/03

- Description
- Operating Summary
- Tests Performed
- Detail Operation
- Test Conditions
- Summary

Specific of D2L107 Test

- Filters are installed downstream of the cooldown and two JT supply lines for D2L107 to prevent any chance of oil contamination - similar to testing D2L105 and 106.

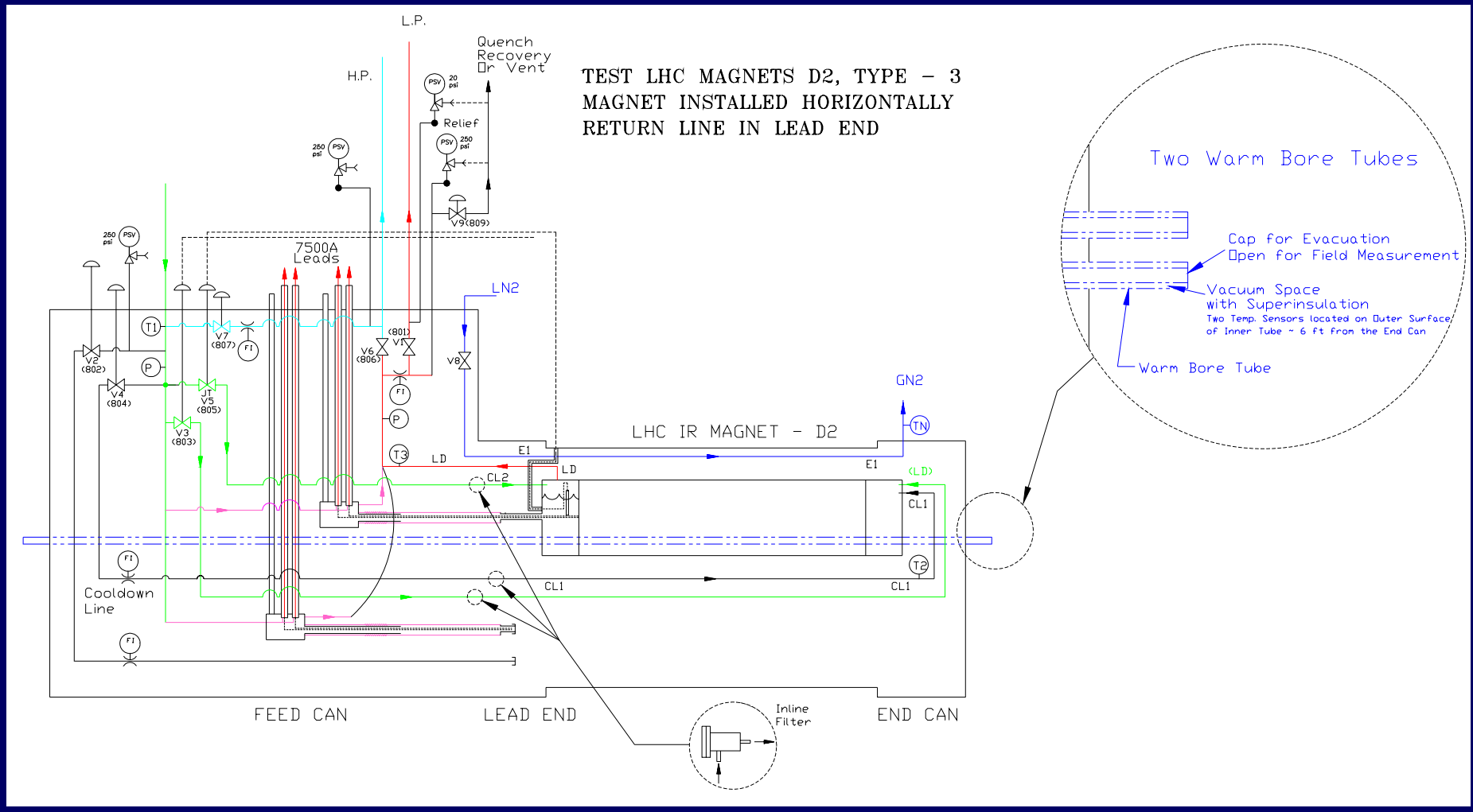
Specific of D2L107 Test

- During 100 K cooldown of D2L107, we have not experienced flow restriction (sign of contamination) as D2L106, 105 & 104.
- After D2L107 is warmed up at the end of the test, an inspection will be performed to check conditions of the filters and the magnet.

General Description - D2L107

- The magnet is installed horizontally on test bay – 0% slope.
- Cooldown/warmup supply in non-lead end, helium return from lead-end.
- In liquid cool mode, JT flows are fed from both ends.
- Warm bore tubes inserted and evacuated during quench tests.
- Warm bore tubes are open for field measurements.
- Information on the Warm Bore Tube and measuring device can be obtained from
    - A. Marone - andym@bnl.gov
    - G. Ganetis – ganetis1@bnl.gov
    - D. Sullivan – dans@bnl.gov

Flow diagram of D2L107 with Warm Bore Tubes, Three Filters, 0% Slope and Return Line from the Lead End.

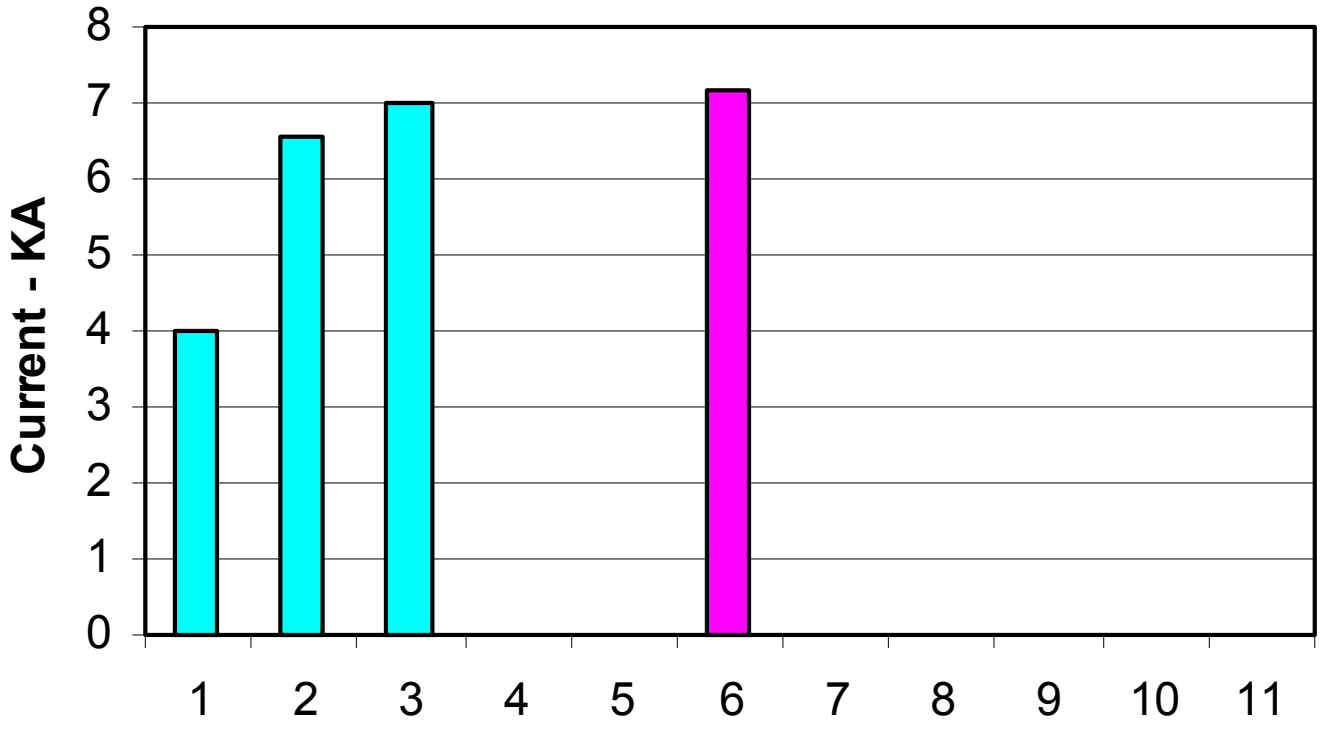


Tests Performed for D2L107

- 1st test group (forced flow cooling ~ 4.60 K),
  - Shut off ~ 160 A (9/15)
  - Strip heater – 4000 A (9/15)
  - 1st quench – 6559 A (9/16)
  - Ramp to 7000 A – no quench (9/16)

- 2nd test group (liquid cool at ~ 4.63 K)
  - Ramp to quench - 7183 A (9/16)

Quench Performance of D2L107
(Warm Bore Tubes Evacuated)



Quench - No. 1 Forced Flow (Strip Heater)
No. 2 Forced Flow (Natural)
No. 3 Forced Flow (7 KA no quench)
No. 6 Liquid Cool

Operation (8/13, 9/10 – 12)

- 8/13 Close vacuum enclosure and establish insulating vacuum. Ready for cooldown.
- 9/9 Due to Regional Power Outage and Labor Day week shutdown, test was postphoned to September.
  Start Cooldown at 2 pm
- 9/10 Cooldown I
- 9/11 Cooldown I – complete in ~ 50 hours
- 9/12 Wait at 100 K

Operation (9/13 – 14)

- 9/13 Start 5 K cooldown using E19 & E20
  Found leads frost badly. Close isolation valves in front of flow controllers to prevent lead failure. Perform diagnosis and found it was caused by wiring modification to split flow signal to the Magnet Test Computer.
  Cooldown with isolation valves closed.
- 9/14 Reach 6 K in the morning.
  Liquid level in Subcooler ~ 8 PM.
  Shutdown E20 and use E19 overnight.

Operation (9/15 – 16)

- 9/15 Reach cold condition.
  Disconnect wires that were added to split signal of flow controller.
  Flow controllers work properly.
  Perform cold check and shutoff at 160 A.
  Strip heater quench.
- 9/16 Quench Test in forced flow cooling.
  1st quench – 6559 A.
  Ramp to 7000 A – no quench.
  Switch to liquid cool
  Quench at 7183 A.

Operation (9/17 – 21)

- 9/17 Work delayed by problems on power supply of the transporter and new software for Magnet Test.
  Field measurement – 1 AC cycle and 1 DC loop.
- 9/18 Field measurement – 1 AC cycle and 6 DC loops.
- 9/19 Field measurement – 1 AC cycle and 4 DC loops. Complete measurement on left bore. Move equipment to right bore.
- 9/20 – 21 Keep at test condition for weekend.

Operation (9/22 – 26)

- 9/22 Field measurement – 2 AC cycle and 5 DC loops.
- 9/23 Field measurement – 1 AC cycle and 5 DC loops. Complete field measurement. Shutdown helium flow to D2. Leave it cold until the data analysis complete.
- 9/24 Start warmup at ~ 2 PM.
- 9/25 Complete warmup.
- 9/26 Open vacuum bellow and disconnect lines from Feed Can. Found the helium supply valve DOV7C on MAGCOOL leak.

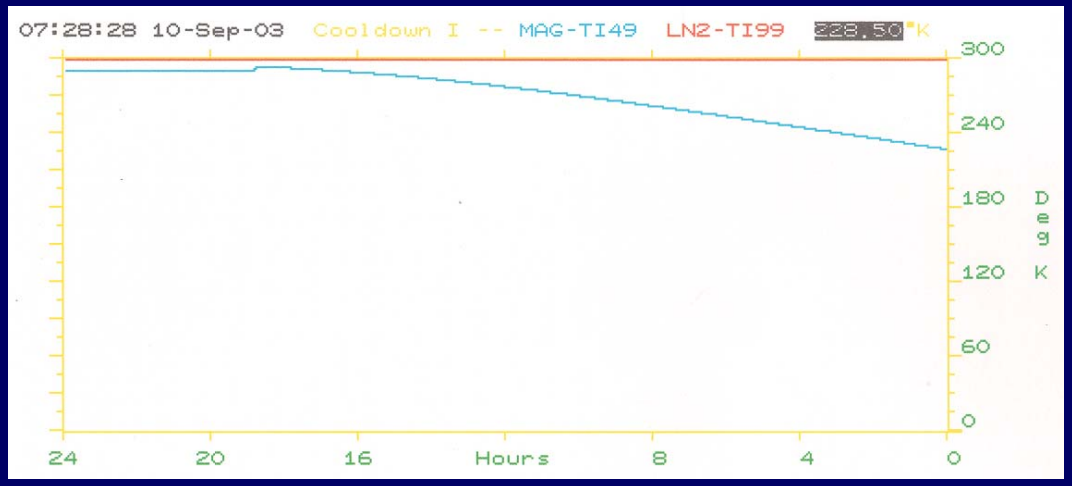
Test Conditions

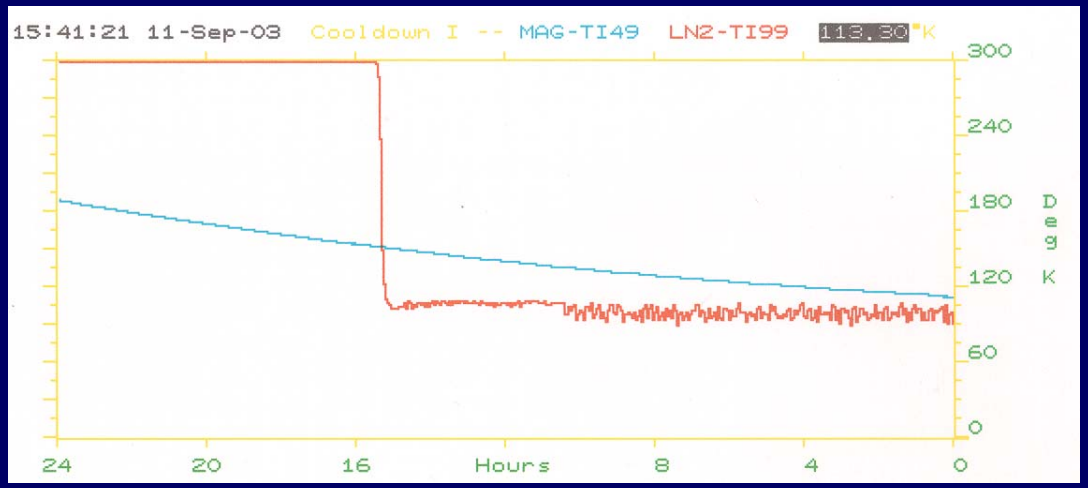
- Forced flow cooling - 12 atm, 4.60 K & ~ 60 g/s
  (Warm bore tube evacuated)

- Liquid helium cooling – 1.43 atm, ~ 4.63 K
  Liquid level ~ 79% (~10 cm above coil,
  ~ 5 cm below vent)
  in both lead end and non-lead end
  (Warm bore tubes evacuated)

Cooldown from 300 – 100 K for D2L107

(9/9 – 9/11/03, Time on display needs to add 1 hour and 30 min)

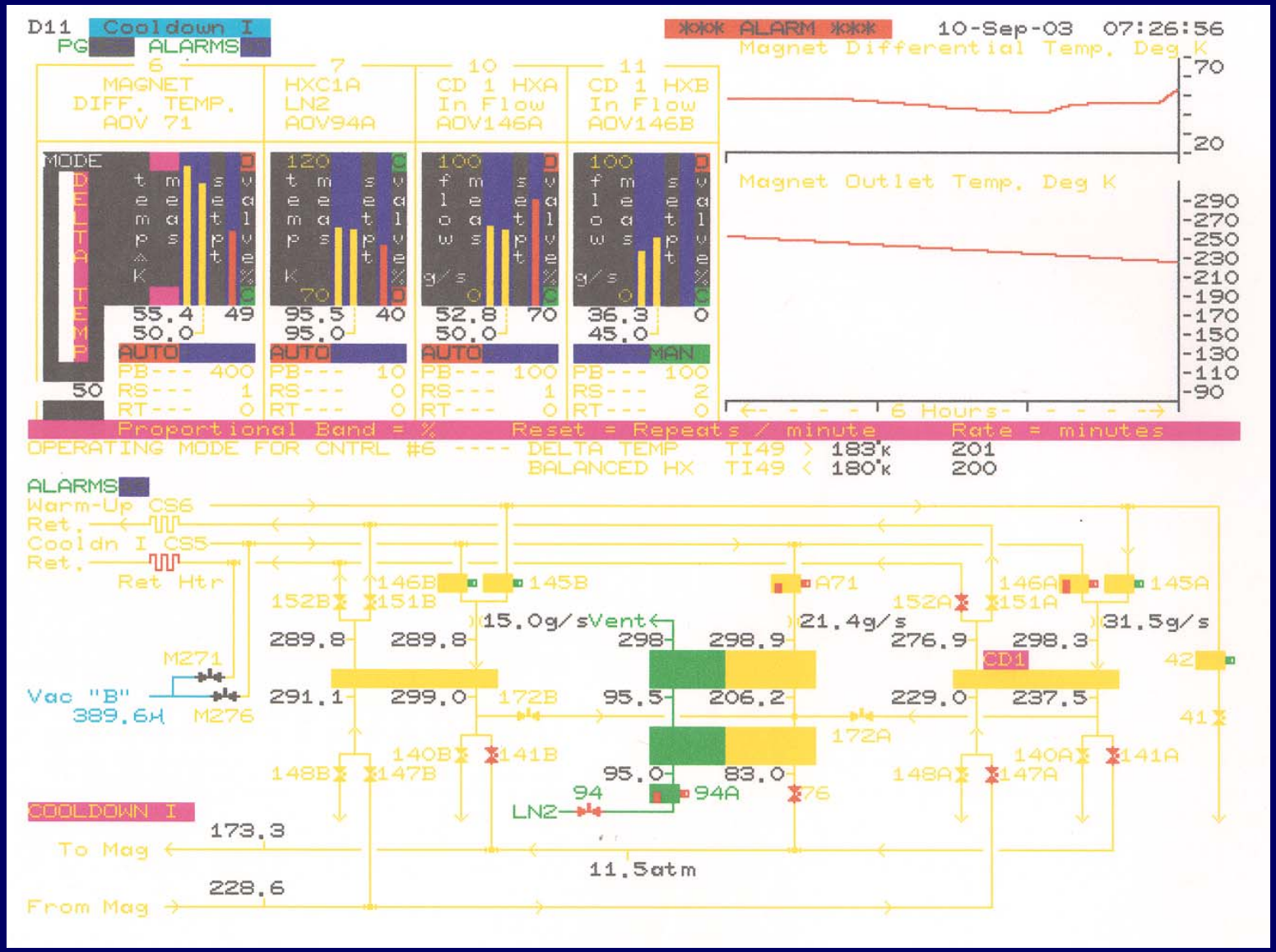




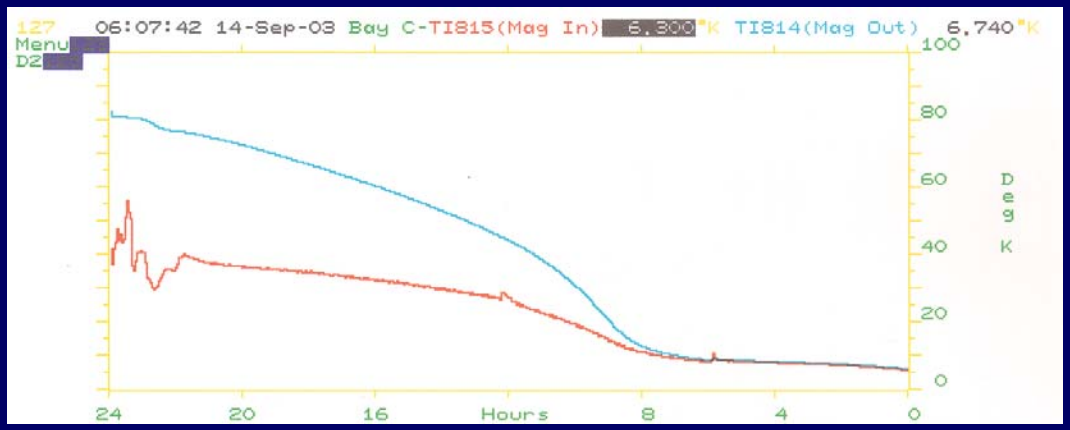
- Total cooldown time is ~ 50 hours
- Cooldown time:

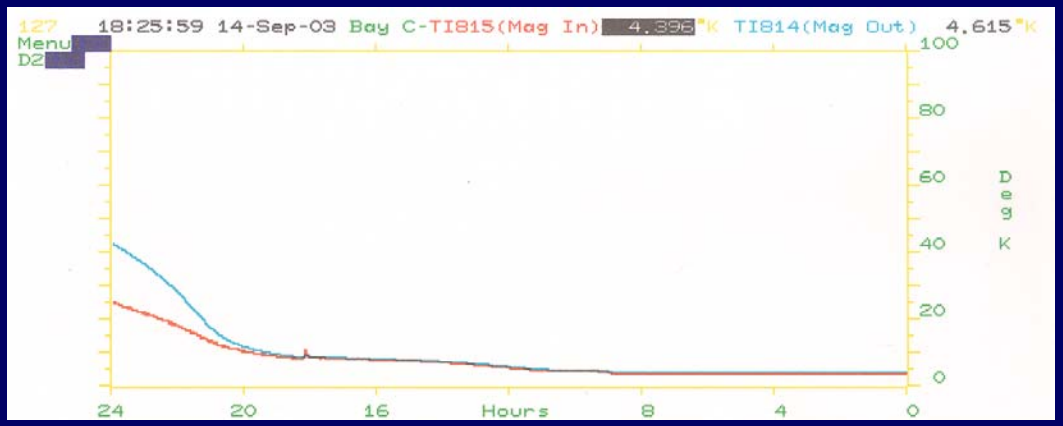
300 – 240 K ~ 24 hours
240 – 110 K ~ 24 hours

Operating Condition for 100 K Cooldown of D2L107



Cooldown from 100 – 5 K for D2L107 (9/13 – 9/14/03)

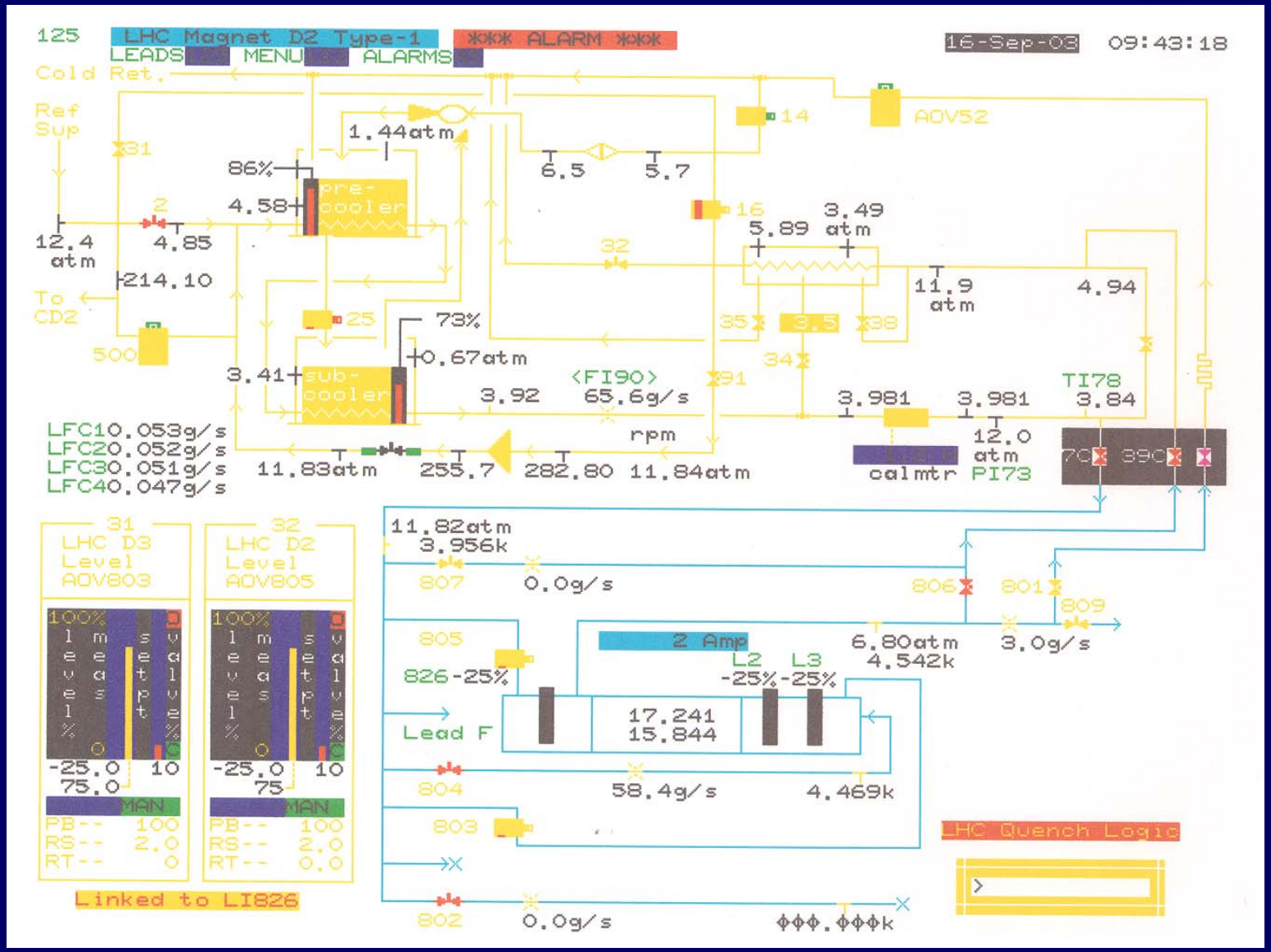




- Cooldown time (90 to 20 K) is ~ 16 hours, using E19 & E20 (~150 rpm).
- Cooldown time (20 to 10 K) is ~ 6 hours, using E19 & E20 (at ~ 150 rpm).
- Cooldown time (10 to 5 K, liquid fill and subcooler pump down) is ~ 12 hours
- Total cooldown time from 90 K to test condition is ~ 36 Hours without lead flow

Forced Flow Cooling of D2L107 Prior to 7000 A Ramping

(Warm Bore Tube Evacuated)

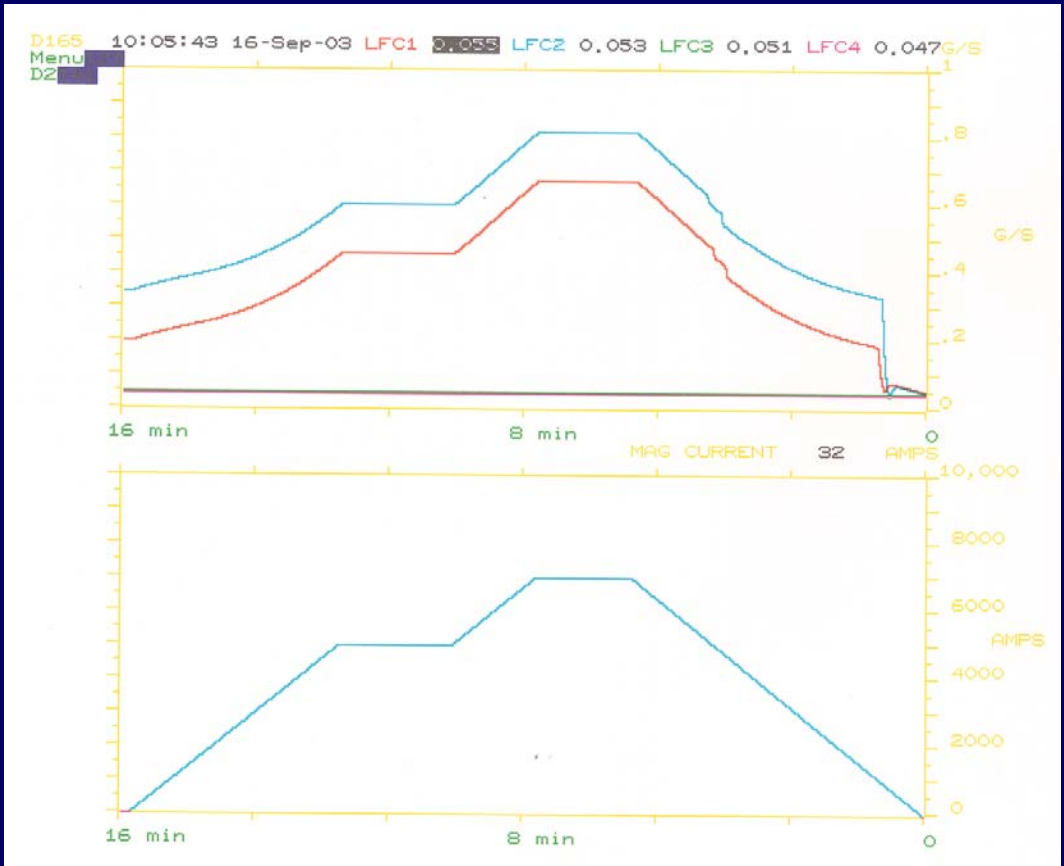


Lead Flow and Current During Ramping of D2L107

Ramp rate is 20 A/s. Below 10 A, Tare flow is 0.05 g/s. Above 10 A, Tare flow is 0.20 g/s for (+) lead & 0.35 g/s for (-) lead. Need to wait for voltage recovery of the (-) lead at 5000 A for ~ 2 min.

Upper Figure: Lead Flow – Blue for (-) Lead and Red for (+) Lead.

Lower Figure: Current as a Function of Time

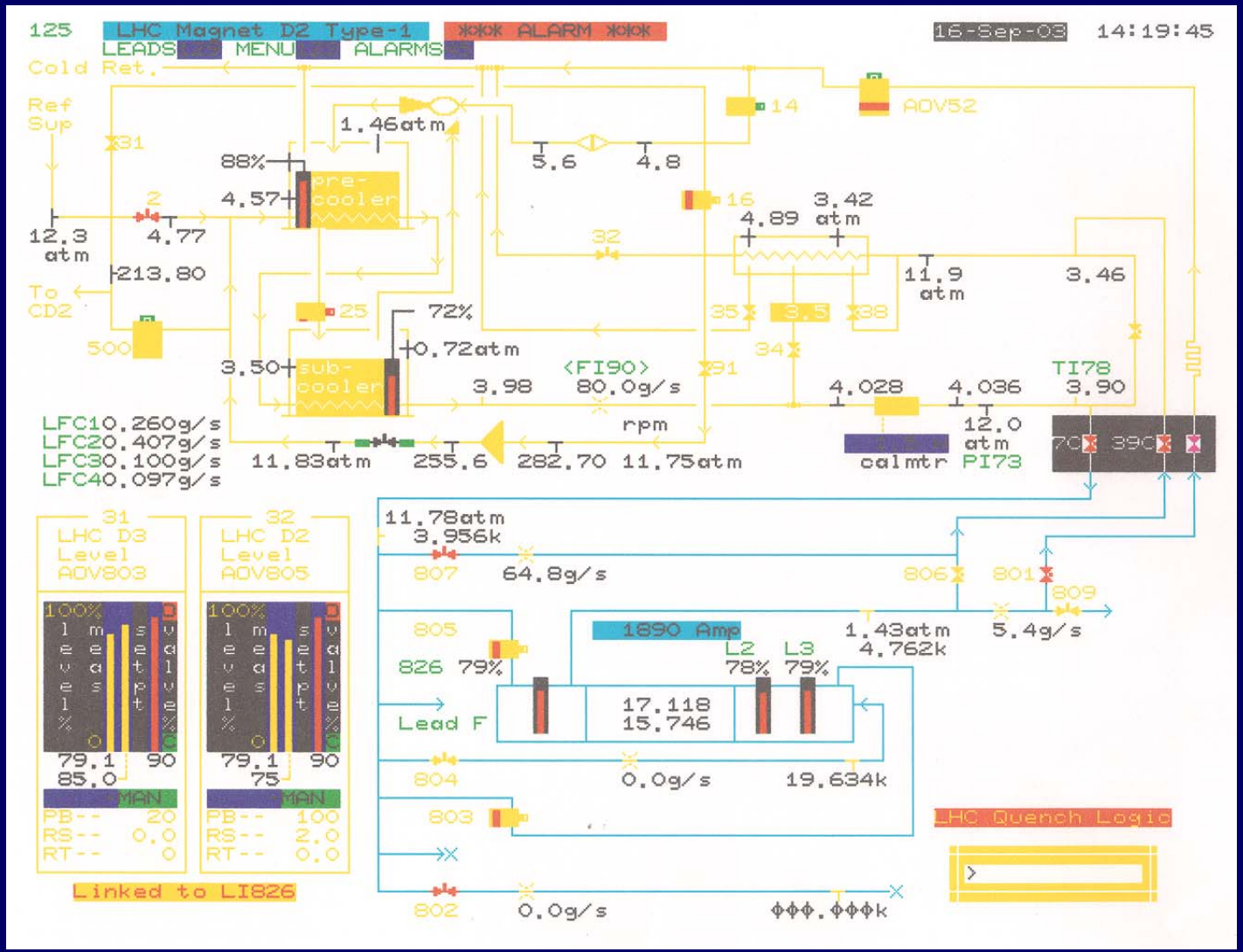


Current Leads

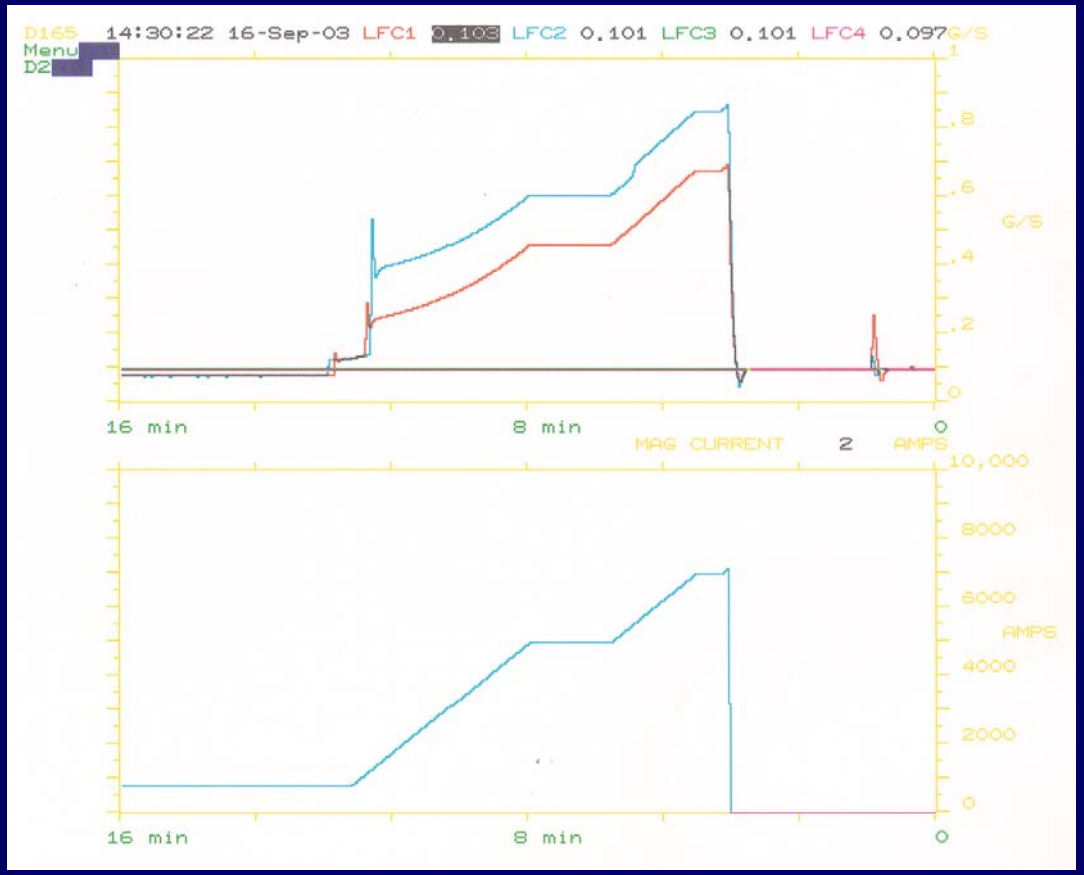
- Operate same way as previous D2 magnets.
- Separate flow controllers for the 7500 A leads. The (-) lead demands more flow than the (+) lead
  - For quench test at 20 A/s ramp rate,
    - The tare flow are 0.20 g/s for (+) lead and 0.35 g/s for (-) lead
    - Wait ~ 2 minutes at 5000 A for the (-) lead to recover the voltage developed before ramping current above 5000 A.
    - After reach the operating current, warm end of the leads could become cold. Small reduction in Tare flow is needed.
    - Unused leads are set at 0.050 g/s for forced cooling and are set at 0.100 g/s for liquid cool.

Liquid Cooling of D2L107 for ramping to 7183 A - Both JT valves 90% open to obtain 79% liquid level

(Warm Bore Tube Evacuated)



Lead Flow and Current During Ramping of D2L107 – Liquid Cool
Ramp rate is 20 A/s. Below 10 A, Tare flow is 0.10 g/s. Above 10 A, Tare flow is 0.20 g/s for (+) lead & 0.35 g/s for (-) lead. Wait ~ 2min for voltage recovery at 5000 A.
Upper Figure: Lead Flow – Blue for (-) Lead and Red for (+) Lead.
Lower Figure: Current as a Function of Time



Problem

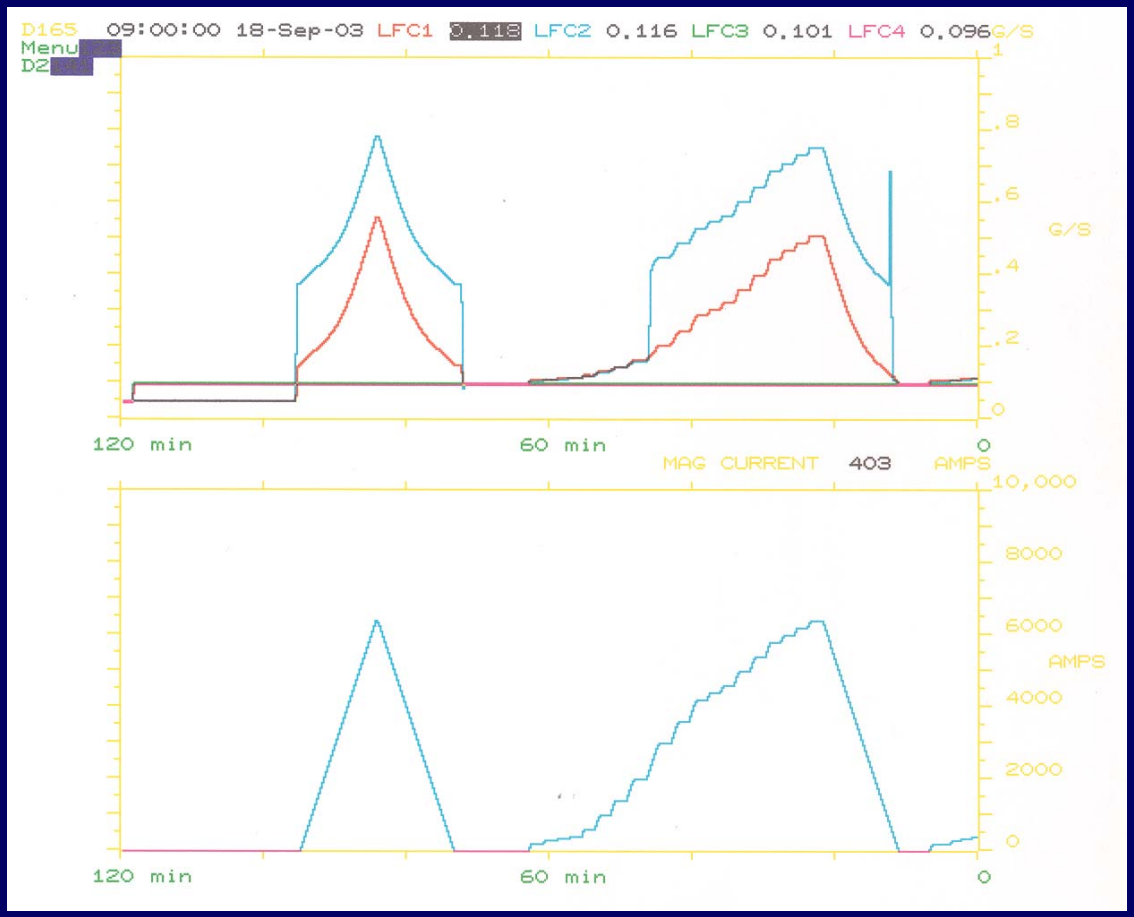
- In liquid mode, we are unable to use the same JT setting as previous D2s in maintaining liquid level in the magnet end volume. Response of liquid level is extremely slow with the JT opening. The two JT valves, one feed the lead end and the other the non-lead end), need to open 90% so that we can reproduce condition for liquid cool as previous D2.
- Early in the test, one level gauge has higher reading than the other two. After re-attach electrical connectors, all three level gauges are consistent.
- The problem is believed from the JT valves and is external to the D2 assembly. Both JT valves will be examined at the end of the test.

Lead Flow and Current for AC Cycle (left) and DC loop (right) are the same as previous D2

Upper Figure: Lead Flow – Blue for (-) Lead and Red for (+) Lead.

Lower Figure: Current as a Function of Time

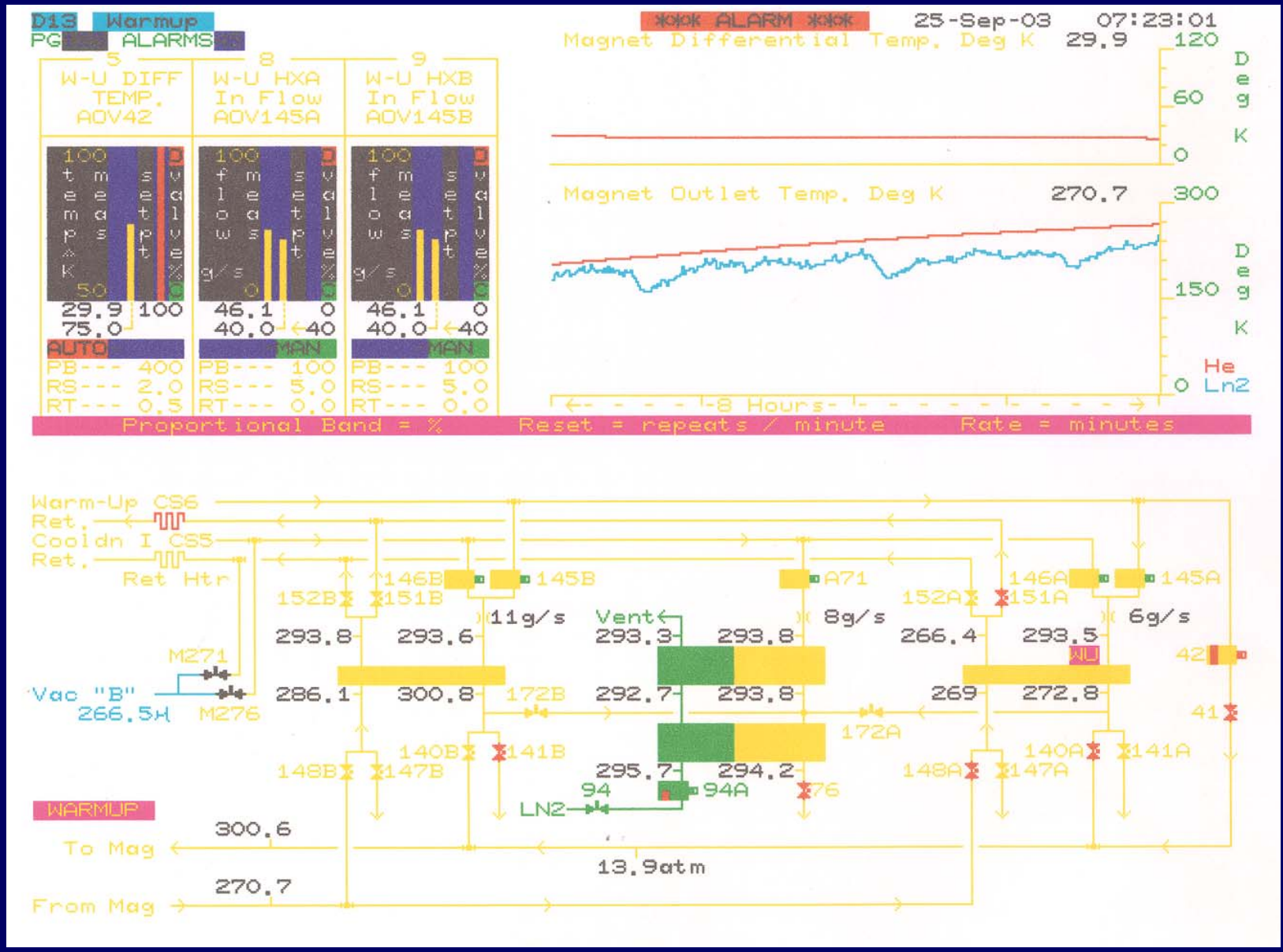
Ramp rate is 10 A/s and is ramped to 6400 A.



Current Leads

- Flow control for AC cycle and DC loop are the same as that for D2L104 & 105
  - For AC cycle at 10 A/s ramp up directly to 6400 A,
    - Tare flow is ~ 0.15 g/s for (+) lead
    - Tare flow is ~ 0.38 g/s for (-) lead
  - For DC loop at 10 A/s with 70 seconds stop at various pre-selected currents,
    - The tare flow is 0.10 g/s for (+) lead for all currents
    - The tare flow is 0.10 g/s for (-) lead below 2000 A and 0.35 g/s afterward, (or reduced back to 0.10 g/s below 2000 A with stop during ramp down)
- Unused leads are set at 0.100 g/s.

Process Control for Warmup D2L107 – 9/25/03



Warmup of D2L107 – from 70 to 300 K

Total time equals ~ 30 hours.